The effect of defects on the electrical and phonon properties of graphene and MoS_2

Adrian Balan[1,3], Liangbo Liang[2], William Parkin[1], Michael Lamparski[2], Paul Masih Das[1], Carl H. Naylor[1], Julio A. Rodriguez-Manzo[1], Matthew Puster[1] , A.T. Charlie Johnson, Jr.[1], Vincent Meunier[2], Marija Drndić[1]

[1] Department of Physics and Astronomy, University of Pennsylvania, Philadelphia, Pennsylvania 19104, United States
[2]Department of Physics, Applied Physics, and Astronomy, Rensselaer Polytechnic Institute, Troy, New York 12180, United States
[3] CEA Saclay, LICSEN, France
adrian.balan@gmail.com

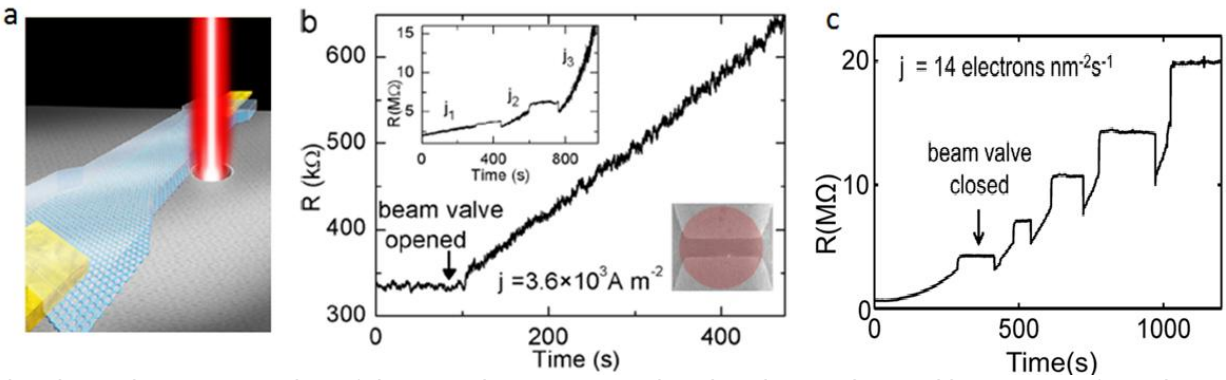
Abstract

We present a comprehensive study of the effects of the defects produced by electron irradiation on the electrical and crystalline properties of graphene and MoS_2 monolayers. We realized electrical devices from monolayer MoS_2 or graphene crystals suspended on a 50nm SiNx membrane. The samples are exposed to electron irradiation inside a 200kV transmission electron microscope (TEM) and we perform in situ conductance measurements [1] and subsequently ex-situ Raman cartography. We correlate the damage to the crystalline lattice - measured by diffraction - with the observed decrease in the two-terminal conductivity of the devices and the variation in the Raman phonon modes. The change in the diffraction pattern is fitted to a kinematic model. The variation of the phonon modes is fitted to DFT simulations. The evolution of the conductivity with the defect concentration is approached in the percolation theory framework, using a resistance network model.

References

[1] M. Puster, J. A. Rodriguez- Manzo, A. Balan, M. Drndic., ACS Nano, 7 (2013), pp 11283–11289

Figures



a) Schematic representation of the monolayers exposed to the electron beam. b) Increase of graphene resistance during electron irradiation c) Increase of MoS_2 resistance during electron irradiation